Procedia Engineering

Volume 143, 2016, Pages 635–641

Advances in Transportation Geotechnics 3 . The 3rd International Conference on Transportation Geotechnics (ICTG 2016)

Constructive Constraints regarding the Stabilization of Slopes near Active Railway Tracks – Case Studies

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Abstract

The stabilization of slopes near active railway tracks adds a few more constructive restraints regarding the choice and design of the subsequent stabilization methods, whether for the need to make compatible the stabilization works with the railway traffic or by need to eliminate additional risks, such as train hits or electrocution. These factors strongly influence the choice of the stabilization methods and the construction processes and phasing, with (not always clear) implication on the total cost of the contract.

In this article, it is presented some case studies, referring to recently developed stabilization works and projects, on active railway lines, looking to highlight the main associated constraints and their respective implications in terms of the prescribed solutions.

Keywords: Slope Stability, Stabilization Methods, Active Railway Tracks, Safety Risks

1 Introduction

The stabilization of slopes near active railway tracks endue great specificity, whether it is for the additional safety risks involved, both for workers and trains, or by need to make the stabilization works compatible with the railway traffic and infrastructure.

For safety purposes, when planning any sort of work near railways, it must be considered the railway traffic and the possible presence of mechanically tensioned overhead contact lines. Regarding the physical constraints, it must be assured that these elements (railway traffic and infrastructure) are duly accounted on choosing construction processes and estimating work productivity. Therefore, it is essential that designers bear these factors in mind, since they pose several implications not only on designing the stabilization solution but also on evaluating budgets and execution time.

In this article, it is highlighted the main constraints and related implications of working near active railway lines, both at designing and contracting level, based on recent stabilization works and projects.

Selection and peer-review under responsibility of the Scientific Programme Committee of ICTG 2016

doi:10.1016/j.proeng.2016.06.090

Hence, we start by pointing out specific risk factors related with these works and, afterwards, briefly describing the primary associated limitations.

2 Risk Factors

Regarding the Portuguese railway infrastructure, both the safety railway parameters and the respective safety measures, to which all works developed on or near active railway tracks must comply, are laid down on and regulated by "Instrução de Exploração Técnica nº 77 – IET 77" (Instituto da Mobilidade e dos Transportes Terrestres, IP, 2009).

In this chapter, we propose to resume the prescripts of this standard, summarizing the critical risk factors as well as the consequential possible safety measures.

2.1 Railway Traffic

When planning an intervention on or near an active railway track, it must be pursuit the elimination of any risk for workers or equipment of being hit by trains. According to IET 77, this risk is related to:

- The maximum design layout speed of the track in the area – the weight of this factor is related not only with the reduction on reaction time, but also with the increase on the suction effect generated by the passing train;
- The distance between workers and the element signaling approaching trains;
- The type and quantity of human and material resources associated with the works – heavy machinery will require a broader demobilization timespan;
- The nature of the intervention - this factor is deeply related with the previous, in the sense that it influences the time needed to demobilize equipment and personnel;
- The distance between the working area and the nearest safety zone.

Considering these parameters, IET 77 defines a risk zone boundary - Figure 1, inside of which there is an effective risk of being hit by a moving train. As so, one or several of the safety measures presented in Table 1 should be ensured. Table 1 also resumes the main advantages and limitations of each of these measures.

2.2 Overhead Contact Line

Another serious risk related to working on or near active railways is the risk of electrocution, considering that a great extent of the Portuguese railway network is mechanically tensioned to 25 kV - Figure 3 (the equivalent to a medium voltage power line, hanging at about 6 m from the ground).

According to IET 77, over a 2 m radius from the tensioned wire (risk zone C in Figure 1), there is a high risk of electrocution. If there is a need to overrun this risk boundary, then all works must be performed during a power break period, which is only possible when the railway traffic is suspended.

In Figure 4 the execution of micro-piles near a railway track is presented. Due to the overhead contact line's proximity, as well as the reduced available space on the embankment platform, there was the need to employ lighter machinery and, consequentially, smaller metallic reinforcement (both in diameter and in length).

Safety measure	Description	Advantages	Limitations
Safety barriers	Bounds risk zone "A" by setting rigid barriers, hence avoiding its overpass.	Practical, cheap and effective.	Requires a minimum sidewalk width. No crossing of risk zone "A" allowed.
Approaching trains warning system (SAAC)	Consists of an announcement system (Figure 2) that warns workers inside risk zone "A".	Manual: practical and easy to set up. Automatic: practical and reliable.	Manual: expensive (allocation of 1 to 2 workers, exclusively). Automatic: high mobilization costs for short time interventions.
Temporary maximum train speed limit	Aims at reducing train braking distance and increasing personnel's reaction time.	Reduces announcement distance and risk area "A" boundaries.	Great impact in train traffic.
Temporary traffic intermission	For works involving light machinery, during circulation gaps and no prospect of affecting the infrastructure.	The safest measure, since traffic is temporarily suspended.	Impracticable in areas with no cell phone coverage or in high traffic lines.
Line suspension	For works involving heavy machinery, inside risk zone "C" or with prospects of temporarily affecting the infrastructure.	Less embarrassment to work productivities.	Generally involves working night shifts, which can be as short as 4h. High operational costs.

Table 1: Safety measures for working on or near active railway tracks

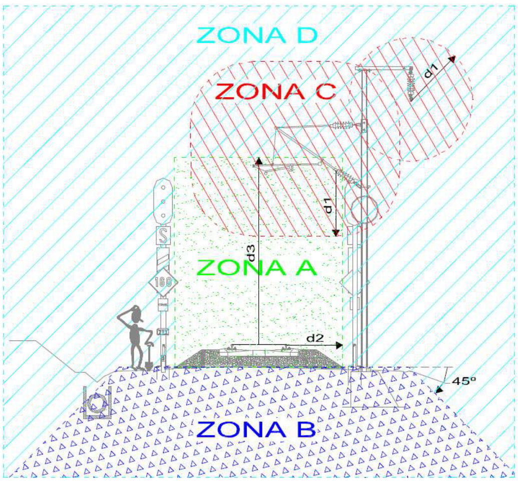

Figure 1: Schematic representation of risk areas **(Instituto da Mobilidade e dos Transportes Terrestres, IP, 2009)**

Figure 2: Detail of a warning system (SAAC)

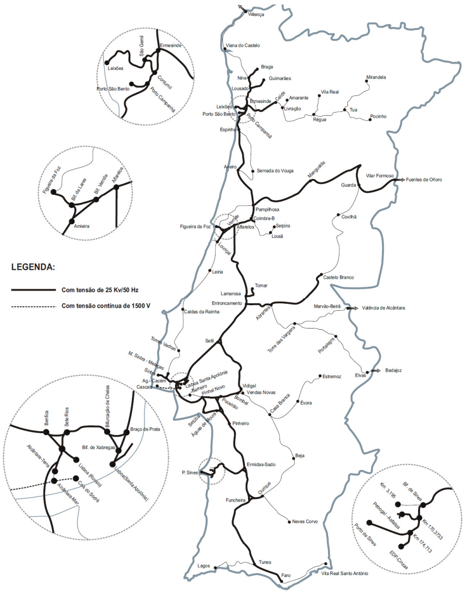

Figure 3: Electrified Portuguese railway network **(Instituto Nacional do Transporte Ferroviário, 2005)**

Figure 4: Execution of micro-piles near the overhead contact line

3 Constraints

3.1 Buried Infrastructures

For the most of the Portuguese railway network, there are infrastructures (rail signaling, communications, overhead earth wire, etc.) running along the tracks, buried in the substructure's platform and near the surface. Usually, the exact information regarding the location of these elements is scarce, coming down just to the side of the track were they run along. Therefore, some preliminary mapping and protection works are required prior to any intervention, as well as returning these elements back to their original layout after concluding it.

3.2 Heavy Machinery Running on Rail Tracks

We have previously pointed out that IET 77 prescribes that all works involving heavy machinery must be performed during rail traffic suspension periods. Furthermore, if these equipments are to be running on rail tracks, it is mandatory to have a special traffic permit. This requirement forces main contractors to use specialized subcontractors, which results in higher fixed costs - Figure 5.

Additionally, when considering resorting to this kind of equipment, one must account not just for the mobilization costs but also for the potential presence of tunnels and other loading gauge limitations - Figure 8.

3.3 Accessibility

In the previous item the factors to account for when accessing the site by the railway track were presented. If it is found that this is infeasible or that alternative accesses are more convenient, one must bear in mind the implications concerning the type of equipment possible to mobilize and, as such, the type of solution prescribed.

Figure 8 illustrates the execution of rockbolts in a slope with high accessibility constraints, on which the contractor chose to resort to manual pneumatic hammers. This equipment has serious limitations to the maximum length and diameter for the rockbolts.

Figure 5: Site investigation works with equipment mounted on a wagon

Figure 6: Loading gauge limitation

Figure 7: Alternative to equipment running on rail tracks by creating a temporary platform

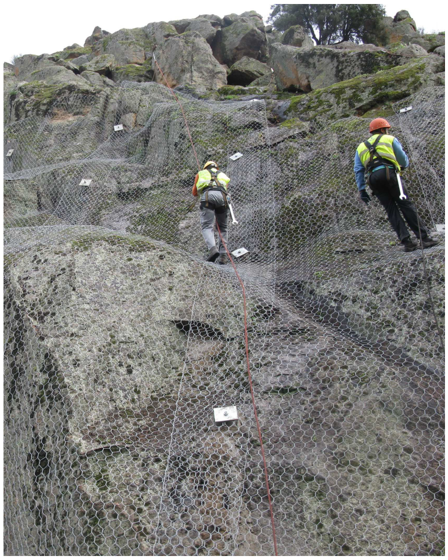

Figure 8: Execution of rockbolts and wire mesh with light equipment

Still relating to Figure 8, another difficulty felt concerned the hoisting of the wire mesh up until the slope crest. These aspects have great impact on the unitary cost of the rockbolts and, in stabilization works of this nature, on the total budget of the intervention.

Another example of the implications due to accessibility difficulties is presented in Figure 6. In this intervention, the concrete supply to the site involved a concrete pump. Combined with a long travelling time (between the concrete supplier and the site), this aspect aroused the need to add retarding admixtures and plasticizers to the concrete. All this factors render a higher unitary cost of the concrete.

3.4 Noise Licensing

As it was previously pointed out, there may often be needed to work night shifts. When the construction site locates in urban or suburban areas, it implies the need for the contractor to obtain a Noise License and, eventually, make noise monitoring. The works presented in Figure 7 concern a slope below a Tourist House; during the summer time, stabilization works were highly restrained, since the contractor had to comply with very strict noise limits (even with a noise license).

3.5 The Douro Line

From the whole Portuguese railway network, the Douro Line represents a very particular case, regarding to slope stabilization interventions, since it is located at an UNESCO World Heritage Centre – the Alto Douro Wine Region. As so, any intervention must be designed to cause minimum landscape impacts. Figure 9 presents one of the most common mitigation measures for exposed concrete faces, using materials from the nearby areas. These are expensive and time-consuming works, which often induces designers to choose different stabilization techniques.

Figure 9: Mitigation measures for impacts on landscape **(Tetraplano Engenharia, Lda, 2010)**

4 Final Remarks

Maintenance works on or near active railway tracks implies great complexity on design and execution due to physical and safety constraints. Most of these constraints, imposed by Infraestruturas de Portugal, S.A.'s internal standards and procedures, have a significant impact in the intervention's phasing and cost estimating. As such, it is essential that both the designer and the contractor are duly acquainted with the implications of these factors, so that their effects can be effectively managed and mitigated.

In this article it is proposed to enumerate the main constraints and pinpoint their implications to the work progress, based on the experience acquired over recent slope stabilization interventions on or near active railway tracks.

5 Bibliography

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